Chapter Ten

Cores and Competencies

With atomic energy in the engine room, guided missiles in the hangars to topside, and the target-seeking homing weapons in the torpedo tubes, the submarine of the future figures to be the instrument of war most benefitted by atomic era science.

—All Hands, Oct. 13, 1951—

By February 1957, *USS Nautilus* had run as far as her first loading of fuel would allow. The boat had traveled 62,562 miles, more than half of them submerged. She had hosted royalty, entertained political leaders, and convincingly played the role of a high-speed enemy submarine in Navy war games. Now she sailed home to Groton, Connecticut, for the delicate process of removing the reactor core and replacing it with a new and better one.

Fuel in the unshielded core emitted gamma radiation so intense that a few moments of close exposure would cause death. The procedure to remove the core from the boat was pre-planned in endless detail. The objective was to move the core into a shielded transport cask and hoist the cask onto a truck. This conceptually simple—but highly complex—task took two months to accomplish. *Nautilus* then sailed away to the Pacific Ocean, and the old core was sent across the country to Idaho.[1]

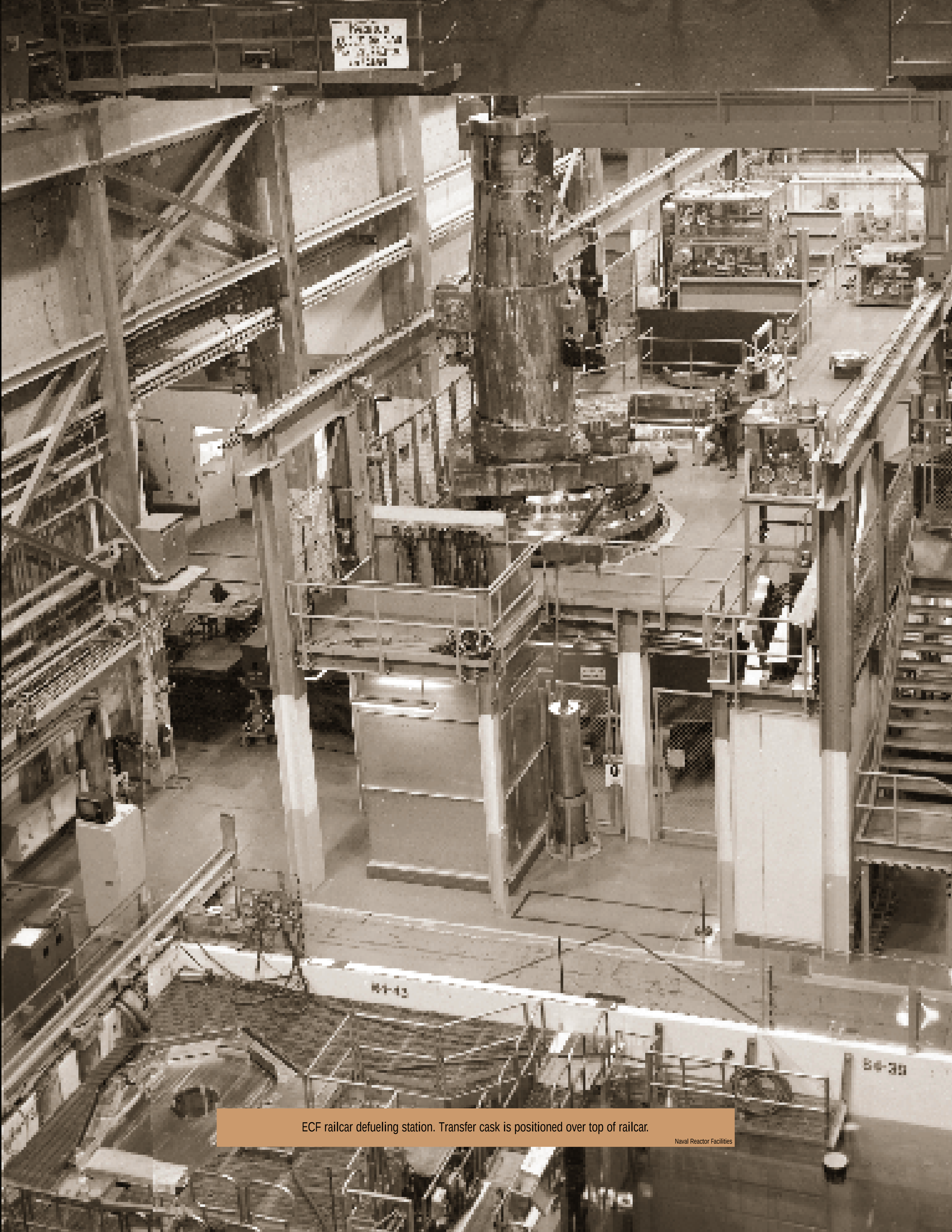
A brand new facility, the Expended Core Facility (ECF), was being readied at the NRTS to undertake the equally delicate task of unloading the cask and placing it safely in a deep pool of water, a procedure that took about three days.

Naval Reactor Facilities 10024

The ECF under construction, looking east toward S1W. Equipment and water pits take shape.

Within the Navy's complex, the ECF was located near the north fence. It began as a building 340 feet long, although its designers expected it to expand as the workload grew. They considered the facility an important continuation of the research and development phase of the nuclear industry. Here were complete reactor cores that had served their missions, not merely sample elements tested in the MTR. Did the fuel operate as predicted? How well did the cladding hold up? How much beyond its design life might the core have lasted? By no means would the Navy rest on the performance of the first cores.[2]

Nor would a commercial power industry, once it had begun. The designers visited Hanford and other places to study how they handled irradiated cores. They hoped the ECF would become a model system, a sound demonstration for the industry sure to come in the future.[3]

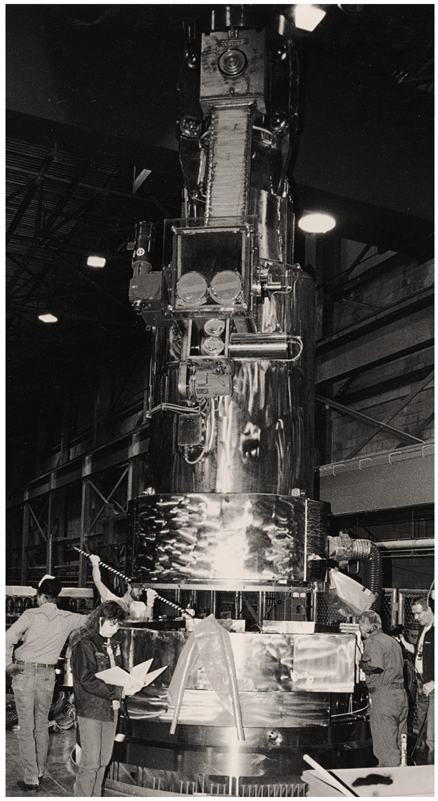


ECF railcar defueling station. Transfer cask is positioned over top of railcar.

Naval Reactor Facilities

The action was definitely underwater within the ECF. The safest way to store the cores and have access to them was to place them in “water pits,” the Navy equivalent to the MTR “canals.” The basic problem was getting close enough to the fuel to handle or study it. When a truck or train car arrived with a load, the first move was to hoist the entire transport cask into the water of a receiving pit and set it down on the (heavily reinforced) concrete floor. After that, subsequent manipulations extracted the fuel from the cask and moved it from one water-pit work station to the next.[4]

Engineers constantly invented or adapted gadgets and machines to do underwater what was taken for granted in the dry, non-radioactive world. Because working with a whole core or fuel element was too dangerous or bulky, they would shear a piece off or punch a piece out. Hack saws and band saws cut and chopped to obtain representative samples. Other instruments measured and weighed them. Periscope ports and observation windows with shielding power equal to the concrete walls of the pits gave visual access into the water. Workers guided the remote manipulators by the light of standard diving lamps. They were quick to try new ways to see through the water. When television cameras were commercially available, they bought one from the local Farnsworth Electric Company, encased it in a stainless-steel can, installed a window in one end, and dipped it into the water. Experimentation was a part of daily work:



Naval Reactor Facilities

ECF workers on the defueling platform above an M-140 railcar prepare to receive fuel into a transfer cask.

ECF Engineering designed an underwater core-component de-scale system [to remove hardened incrustation on metal parts] in late 1962. This included an inner vessel ...encased in an outer vessel, [each] with a bolt-on top and seal. The void space between the vessels was pressurized with air to displace the water after the component was loaded; then the inner vessel was pumped full of de-scale solution and circulated while being heated...

It operated for a time with moderate success...until the inevitable happened, the top cover seals failed. Water pits #1 and #2 were “deep purple” for a week, and it was several months before all trace of purple color was gone. That event ended the underwater de-scale operation.[5]

And unusual events occasionally produced a “lesson learned.”

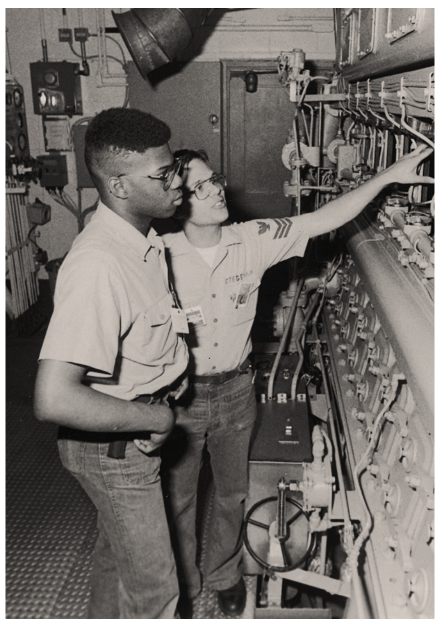
A rail car container crashed through the closed west-end roll-up door number 6 one morning during car switching operations. The rail car uncoupled from the switch engine and slowly rolled through the closed gate and the closed door. The surprised crafts foremen and others threw tools and wood blocks in front of the wheels to bring the railcar to a stop before it ran off the end of the rails and into the water pit. One immediate corrective action was to install rail stops at the end of the tracks by the craft offices, and of course the other actions were to replace the fence gate and the roll-up door.[6]

After the shearing and milling operations, the portions of fuel that would not be examined further were moved through the pits and out of the building to the Chemical Processing Plant. Other non-fuel solids went to the NRTS Burial Ground.

The ECF inspected and analyzed the fuels from S1W and the other Idaho prototype reactors in addition to fuel from *Nautilus*, *USS Seawolf*, and other vessels. The original plant was designed to process three cores a year

Right. Rickover at hull entrance to S1W prototype. Below. Navy students in training onboard S1W prototype.

Naval Reactor Facilities



Naval Reactor Facilities

per shift, but new business required expansion. In addition to fuel from the vessels of the growing Nuclear Navy, MTR-irradiated specimens came to ECF scientists. Spent fuel from the Shippingport reactor was shipped to the ECF from Pennsylvania for examination. The detailed examination of nuclear fuels accomplished its purpose. Reactor fuel improved. Structural alloys and cladding improved. Over time, inspections grew more precise and more exacting. The life of a ship core eventually matched the design life of the ship itself, twenty years or more. By 1989, the ECF building had grown to a length of a thousand feet.[7]

Greater work loads—and larger cores—generated more risk of exposure to radiation, and protection strategies grew ever more sophisticated. In the earliest days, people leaving work areas—not only at the Navy facility but elsewhere at the NRTS—submitted themselves to "friskers," hand-held probes that scanned hands, shoes, and perhaps the whole body for radioactivity. Nearby were rolls of tape, so that a worker could remove a hot particle by a press of the tape and leave it in a collection can. But experience and innovation produced ever cleaner work areas.

It was not uncommon to press off a hot [particle] almost every time one left the high bay. Next came shoe covers for entry into the high bay. Then came the requirement to cover the hot spot with tape and proceed to the radcon [radiation control] field office, where the rad techs removed the particle and saved it for isotope identification and foot trail mapping for possible pickup location. Better radiological work practices, deck oil mopping, and improved anti-C[ontamination] clothing and laundering all contributed to significant reductions in particle spread.[8]

Elsewhere in the Navy complex, the reactor prototype program also was growing. Admiral Rickover had sent the first crew of the *Nautilus* to train at S1W in Idaho. After that, training seemed an obvious mission for the reactor, to the lifelong gratitude of generations of young women in the neighboring towns. When each trainee arrived in Idaho, he had a few days to find and settle a place to live. One in four of the trainees married before his six months of training were over, and it wasn't unheard of for a man to meet, court, and marry, all in his first two weeks.[9]

Rickover's ideas about the training of nuclear plant operators were controversial within the Navy. He wanted to train a new type of naval officer, unfettered by what Rickover saw as the useless traditions embedded in regular Navy training. On the basis that assuring safety aboard ship required that all ship personnel be able to evaluate potential hazards, Rickover had his way. He

Some of Admiral Rickover's Favorite Aphorisms

Employees at the NRF used to hang plaques around the place to remind themselves of the Admiral's philosophy on Life and Time.

Heaven is blessed with perfect rest. The blessing of earth is toil.

Every hour has sixty golden minutes, each studded with sixty diamond seconds.

When you waste your time, remember even God cannot undo the past.

In this school, the smartest work as hard as those who must struggle to pass.

The secret of success: late to bed, early to rise, work like hell and you'll be wise.

Hal Paige

established a system of nuclear training schools, and the desert prototype was an essential part of it. Rickover supervised the preparation of textbooks and ordered that no examinations contain multiple-choice or true-false questions. Tests required essays, definitions, statements of fact, or calculations. Homework was required, and since it often involved classified material, trainees had to do it on the premises, not at home.[10]

The controlling philosophy was self-responsibility. Rickover rejected simulations in favor of real reactors. "You have to train people to react to the real situation at all times. But if they are trained with a simulator, they tend to expect there will be no consequences," he said. Rickover didn't want to train the wrong instincts by using a machine that could not mimic a real nuclear power plant under real-time conditions, including casualties. Computers capable of doing this were not available at the time. Cross-training also was important. Electricians should know mechanical systems, for example. Trainees came to the desert after six months of theoretical instruction from a specialty school elsewhere in the system. In Idaho a trainee began by picking up—or trying to—a "triple-hernia-sized" crate of operating manuals, instructions, and schematics.[11]

Using the books and seeking the instructors he needed, the trainee traced every system, component by component. Enlisted men, no less than officers, learned and used technically accurate vocabulary, no nicknames or shortcuts. Common language tended to level everyone; it wasn't unusual for a petty officer 3rd class to be instructing an officer. Due to the prevailing Idaho practice—at least in the early years—of wearing civilian clothes, visiting Navy brass from the regular Navy were in for

Naval Reactor Facilities

A1W under construction. Photo, circa 1956, shows S1W spray pond in foreground.

new experiences. An admiral once toured the S1W prototype and then stayed for lunch with his guides. Later he learned who the men were. "Enlisted men! I thought they were college physicists!"[12]

When he felt competent in a system, the trainee sought an instructor to examine him and sign his checklist. Mastery gradually produced a long list of signatures. The trainee then stood watch at one of the operating stations in the hull. At first, he was paired with a more experienced mate, but then he himself was in charge. Learn one station, move to the next. The trainees started the reactor plant, took it up to full power, maneuvered, shut it down, repaired it, maintained it. Although the nuclear program attracted the top two percent of the Navy's enlistees, some men wiped out, usually because of a failure of self-initiative, not academic insufficiency. There were few second chances. The story is told that one hot summer day, a few sailors took a refreshing but forbidden dip in a cooling-water pond on their way home. Caught, they were dismissed.[13]

The training program grew more complicated as nuclear fuel evolved and as the Navy adapted nuclear power to surface vessels. In 1958 a second prototype, A1W (Afor aircraft carrier), went critical in a new building west of S1W. The prototype actually consisted of two reactors, "A" and "B," which powered one propeller shaft, a "first" that the NRF quickly added to its list of credits. The arrangement simulated Engine Room Number Three of an aircraft carrier, the first of which was *USS*

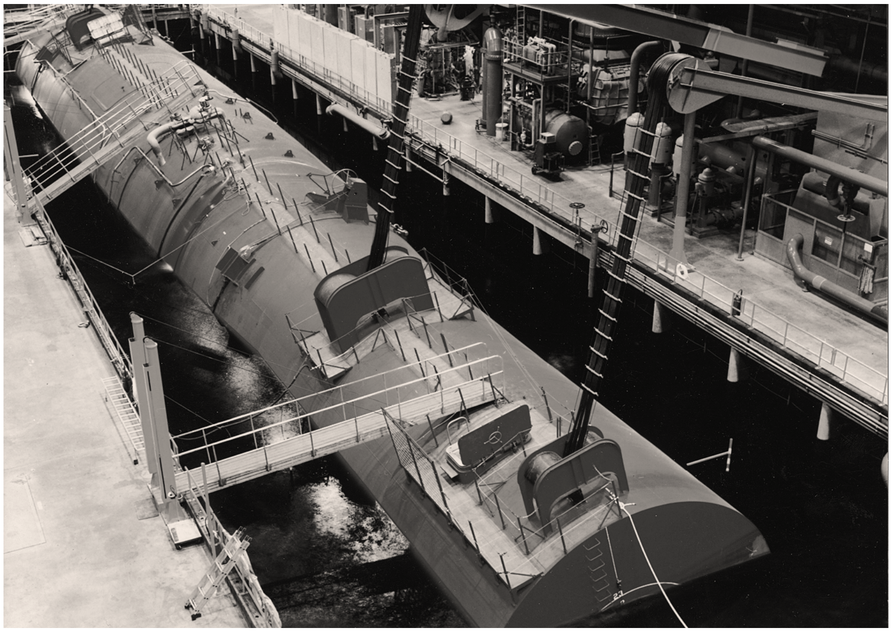
Naval Reactor Facilities

1950s photo showing A1W in center view. Round-top structure on roof is an all-weather shelter for a crane.

Enterprise, a mammoth ship containing eight reactors and four engine rooms. On aircraft carriers, there is room outboard of the reactor compartments to put other equipment or offices. To make those areas habitable without stay-time restrictions, the compartments needed to be shielded on the sides. The A1W prototype, therefore, did not require testing in a tank of water.[14]

The conventional steam plant aboard non-nuclear aircraft carriers supplied energy to catapult airplanes off the decks. When nuclear reactors took their place, they operated at temperatures not as high as conventional plants. Producing a sufficiently powerful head of steam for the catapult therefore required some adaptation of operations. A series of experiments at A1W simulated catapult launches using steam draw-down from the reactor. Each test produced a terrific boom that rolled across the desert and might have reminded Naval Proving Ground veterans of the good old days at the gunnery range.[15]

Then in 1961 came the S5G prototype (the 5th submarine design, made by General Electric). As the Cold War intensified, the United States and the USSR poured their latest technology into the theory and practice of undersea warfare. They wired the ocean floors with sound detectors. These called forth technology to quiet the submarines. One source of noise came from the pumps that circulated the coolant through the reactor and kept it under pressure. The art of sound detection became so refined that skilled listeners could identify the unique sound patterns of individual boats. So the mission of S5G was to eliminate noise.[16]



The S5G prototype floating in its basin.

S5G, like S1W, was built in a huge box of a building, its roof presenting an inscrutable flat surface to satellite cameras passing overhead. The reactor went critical for the first time in September 1965. The hull section floated in a "basin" of water. Operators inside the hull used equipment to make the hull rock back and forth, adding more realism to the simulation. In this setting, the Navy developed a method of circulating the reactor's cooling water without using a pump and exploiting the principle that warm water rises. *USS Narwhal* was the first boat equipped with the system. At high speeds, pumps were still needed, so the controller could move the coolant either by so-called "forced" or "natural" methods.[17]

Rickover made sure that the thousands of Navy trainees who came through the program at Idaho—and the contractors who designed and built the Navy's reactors—were exposed to his philosophy of safety. The men in a nuclear-powered submarine had no avenue of escape in the event of an accident. Therefore, safety engineering and training had to guarantee that accidents would not happen. Every feature of the machine, beginning with its design, had to be completely free of error. Safety lay in the perfection of parts, components, and assemblies. Ultimately, the most important safeguard was human competence—trained, tested, reliable.[18]

This approach contrasted somewhat with the general philosophy employed by the AEC in creating the reactor testing station in a remote location. If accidents were to occur, then a combination of isolation and engineering safeguards would reduce the consequences. Later, when the AEC began to license commercial reactors, its approach to the public's safety continued to rely on

Rickover on Responsibility

Responsibility is a unique concept: It can only reside and inhere in a single individual. You may share it with others, but your portion is not diminished. You may delegate it, but it is still with you. You may disclaim it, but you cannot divest yourself of it. Even if you do not recognize it or admit its presence, you cannot escape it. If responsibility is rightfully yours, no evasion or ignorance or passing the blame can shift the burden to someone else. Unless you can point your finger at the person who is responsible when something goes wrong, then you have never had anyone really responsible.[19]

Admiral Hyman Rickover

S1W on the day of Admiral Rickover's death, July 8, 1986.

remoteness and engineering safeguards. Rickover, by instituting management systems for "quality," was considerably ahead of the rest of American industry.[20]

Rickover preferred to visit the NRF with little or no advance notice, partly to avoid wasteful ceremony and partly to observe conditions as they were, unvarnished and unpolished. However, this didn't mean that his hosts preferred to be surprised. People did what they could to predict his trips to the NRTS so they could be as well-prepared as possible.[21]

Whether he was expected or not, Rickover visits left memorable impressions on the people who met him. Stories about the man were passed on to a new generation of NRF workers who had not known him. Secretaries from steno pools recalled standing by to take dictation while he waited for airplanes. He liked to collect silver dollars, commonly in circulation in the 1950s, so office cashiers checked their supplies and polished them up. Outdoors, groundskeepers gathered up cigarette butts and repainted fire hydrants if they didn't look bright enough. One story (among many others) is retold with many variations in it:

Admiral James D. Watkins, Chief of Naval Operations, came to the NRF to speak at an officer graduation ceremony [or for a visit.] On his way to the NRF, a guard stopped him for speeding [or for not having a security badge]. "Do you know who I am?" Watkins asked the guard. The guard said, "No sir, but you're not short and you don't have white hair, so you're not Admiral Rickover."

"What would you say if I told you I were Rickover's boss?" said Watkins. "Then I'd know you were lying, sir. Rickover ain't got no boss."[22]

The stories celebrate a man who by the sheer force of his brilliance, wit, and dedication created an institution as complex and world-changing as the Nuclear Navy. An abiding respect continues for Rickover's simple belief that there was no room for error aboard nuclear-powered submarines.